Correlation of Radula Tooth Structure and Food Habits of Three Vermivorous Species of *Conus*

BY

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(Plate 47)

Members of the genus *Conus* have the most complex individual radula teeth of any mollusk. Each tooth is formed of a single sheet of chitin which is rolled as a sheet of paper is rolled, and is variously ornamented externally. The teeth are asymmetrical and difficult to represent completely in line drawings (Plate 47, Figures 1, 2, 3). For more detailed descriptions of these teeth and for figures of the variations the papers of Cotton (1945), Piele (1939), Warmke (1960), and Clench & Kondo (1946) should be consulted. Apparently the rolled chitin sheet has a considerable amount of plasticity for the individual teeth of the various *Conus* species vary greatly in shape and in type of and arrangement of ornamentation such that individual species may, in some cases, be distinguished from congeners on the basis of tooth structure alone. Piele (*op. cit.*) gives an appreciation of the range of variation found in the genus in his illustrations.

This variation in shape and structure among species was noted by several workers, but it was not until 1939 that Piele arranged the teeth into groups of species with similar structure. Since then many workers have figured *Conus* teeth including, in addition to those mentioned above, Barnard (1958), Hanna (1963), Endean & Rudkin (1965), and Von Mol, Tursch & Kempf (1967), but only Endean & Rudkin have attempted to relate a type of tooth structure to a specific prey utilized by the species. They describe the general shape of the teeth of fish-eating, mollusk-eating and worm-eating species, using Piele's categories. While they describe in some detail the structural features common to the teeth of the first two groups, by far the greatest number of *Conus* species feed on polychaetes and other worm-like invertebrates such as enteropneusts (Kohn, 1959; 1968). Endean & Rudkin do not attempt to relate the features of radula structure of the few vermivorous species they studied to particular types of prey. They merely note that all vermivorous species seem to have a spur or cone on the base of the tooth, and that the teeth are rather short and squat in appearance.

Since the great majority of *Conus* species are vermivorous and since the teeth of these species have a considerably wider range of interspecific variation in structure than those in either the known fish-eaters or mollusk-eaters, it is of interest to ask if in fact it is possible to correlate certain structural features of teeth or entire tooth structure with particular types of prey organisms.

During the course of an investigation of the food habits of *Conus* species from Indonesian waters and from West American waters, I dissected 6 specimens of *Conus zonatus* Hwass, 1792, 2 *C. imperialis* Linnaeus, 1758, and 3 *C. brunneus* Wood, 1828 (Plate 47, Figures 4, 5, 6). The only remains found in the digestive tracts of *C. zonatus* and *C. brunneus* were the setae of members of the polychate family Amphinomidae, a rather unusual family for *Conus* to prey upon (Kohn, 1959). I found nothing in the 2 *C. imperialis,* but Kohn (*op. cit.*) has shown them to feed primarily upon amphinomids. Since the radula teeth of *C. brunneus* were known to me to be quite distinctive, I was stimulated to ask if the radula teeth of *C. zonatus* and *C. imperialis* were also similar.

I subsequently checked the radula teeth of *Conus zonatus* and *C. imperialis,* and they also proved to be highly distinctive and very similar to those of *C. brunneus* (Plate 47, Figures 1, 2, 3). It thus seems reasonable to assume that this particular type of tooth structure is somehow useful in predation on amphinomids. Since this

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tooth structure is unique among the various *Conus* tooth types, I would suggest that other *Conus* species showing a similar type of tooth can also be expected to feed on amphinomids. For example, Von Mol, Tursch & Kempf (1967) figure the radula tooth of *C. regius* Gmelin, 1791 which has a structure similar to those of the 3 species discussed here, and thus I would expect it to be a predator on amphinomids.

The fact that *Conus* species prey on amphinomids at all is quite remarkable. The family Amphinomidae is a relatively small one distributed primarily circumtropically. The species are commonly known as "fire worms" (Day, 1967). This name derives from the fact that they have large, long, hollow setae which break easily upon touch and release contained poison into the lesions. This causes severe itching-burning sensations in man (Cleland & Southcott, 1965). Day (1967) gives a concise discussion of the family and good illustrations of setae and worms. Why these few *Conus* species should choose to specialize in eating such formidable prey remains unknown as do the mechanisms which allow the *Conus* to consume the amphinomid without damage to itself.

Amphinomids usually live under coral rock or other rock or in crevices in rocks in shallow water. They are usually fairly large worms which feed on sponges, ascidians and hydroids (Day, *op. cit.*).

Amphinomids are rarely, if ever, taken by other *Conus* species. Kohn (1959, 1968) does not report amphinomid remains from any other *Conus* species and dissection of 1 300 *Conus* of 39 vermivorous species from Indonesia turned up only a single instance of amphinomid remains in a *Conus* outside of the described amphinomid eaters. This was in a specimen of *Conus eburneus* Hwass, 1792. However, the amphinomid eaters occasionally take other polychaetes. In a sample of 13 *C. imperialis* from the Seychelle Islands, one specimen was found to have eaten an unidentified species of the polychaete family Eunicidae. Thus far, the few specimens of *C. zonatus* and *C. brunneus* which have had food in them had only setae of amphinomids, but the number of specimens examined remains too small to make meaningful statements about the amount of the diet composed of amphinomids.

Figures 1 to 3 of Plate 47 show that in all 3 amphinomid predators each tooth has a small barb just back from the tip, followed by a very distinctive series of two large barbs about a third of the distance down the tooth shaft. *Conus brunneus* has 3 such barbs, *C. imperialis* and *C. zonatus* have but 2. The third barb of *C. brunneus* appears to be an accessory barb of one of the 2 large barbs. One of the latter protrudes at a slight angle from the long axis of the tooth and bears a set of denticles on its upper surface (Plate 47, Figures 1, 2, 3). The presence of these 2 barbs and of the denticles on the ridge of one of the barbs distinguishes the teeth of these amphinomid predators.

The remainder of the tooth is unornamented, but the base of the tooth is large with 1 (*Conus brunneus*) or 2 (*C. imperialis, C. zonatus*) protruding prominent bumps which can be termed spurs.

The teeth of these 3 species are also very thick and massive when contrasted to most other species of *Conus*, and the radula sheaths each contain fewer teeth than are normally found in other vermivorous *Conus* species (usually 4 to 6 immediately usable teeth in that part of the radula sheath adjacent to the esophagus as opposed to 8 to 15 in other vermivorous species that I have investigated). The teeth are large as indicated by a low shell length to tooth length ratio. This ratio averaged 25.1 for 13 teeth from 3 specimens of *C. brunneus*, 20.3 for 10 teeth from 2 *C. imperialis*, and 30.4 for 10 teeth from *C. zonatus*. Most vermivorous *Conus* species have shell/tooth ratios of from 30 to 70 indicating small teeth (Kohn, 1963).

It is worth noting that the similarity in radula structure and food habits is not reflected in shell morphology (Plate 47, Figures 4, 5, 6). Whereas *Conus imperialis* and *C. zonatus* have similar tapering shells with straight sides, *C. brunneus* has a convex outline to the body whorl and is a shorter and more obese shell. It also lacks the striking color patterns seen in *C. imperialis* and *C. zonatus*. The aperture is wide in *C. brunneus* as contrasted with the other 2 species, and the interior is not partially obstructed by an internal ridge as is the case in *C. zonatus*. These differences in shell morphology would seem to disallow the use of any shell characters in predicting food in this group whereas this does not seem to be the case in the fish eating *Conus* species, all of which seem to be characterized by a wide aperture. It should be noted that *C. imperialis* and *C. zonatus* are considered to be closely related, and the color patterns are often more similar than the present figures suggest.

This paper is but the first attempt to correlate specific types of radula teeth with particular prey organisms among the vermivorous *Conus* species. The teeth of the species described here are very distinctive and have been shown to correlate with a distinctive prey type. However, the great majority of radula tooth types found in the vermivorous *Conus* species have not as yet been related to specific prey types and other such correlations should be looked for among these types. It is hoped that this paper will stimulate this work.

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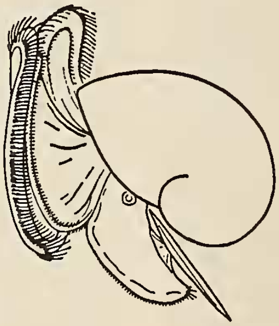

Explanation of Plate 47

Figure 1: Radula tooth of *Conus zonatus*
Figure 2: Radula tooth of *Conus imperialis*
Figure 3: Radula tooth of *Conus brunneus* (scale = 0.5 mm)
Figure 4: *Conus zonatus;* length 58.3 mm, A. J. Kohn coll. no. 4384
Figure 5: *Conus imperialis;* length 72.2 mm, A. J. Kohn coll. no. 1728
Figure 6: *Conus brunneus;* length 46.1 mm, J. Nybakken collection